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Subject: Hardened Intersite Cable System Pressurization Simulation,
Wing I,

Reference: CCN 421

Work Done in Support of CCN 421

RCA designed and built electric pneumatic simulators to conduct simulated pneumatic test on the Hardened Intersite Cable System to establish the parameters of pressure loss in the HICS. The work by RCA was done in three parts:

- A. A simulator unit was built for Flight A and its operation was demonstrated.
- B. Simulators for the remaining 14 flights were built.
 1. The pressurization system of each flight was simulated.
 2. An analysis of each flight's pneumatic system was made.
 3. A report was written for each flight.
- C. A final report covering complete Wing I test results, conclusions, and observations was written.
 1. A wing simulation was performed and an analysis of the simulation made.
 2. The mechanics of operating the simulator units and methods of analyzing simulated data was explained.

Technical comments on A and B above were written by The Boeing Company, reference (b) in cover letter. This letter is the concluding comments on the total effort delineated above. Further field verification work is being done with the RCA simulator units to both increase understanding of the flight pneumatic system and to determine the limits of the usefulness of the simulators. A report of this further effort will be made under a different CCN number.

Simulator Limitations

The simulators were built to simulate a steady state air flow. This air flow is the result of air leakage from the cables. The energy required for air flow to the cable leaks causes the drop in pressure of the cable system. A cable system with no leakage would contain static air and would have no pressure drops to be simulated by the simulator units.

The more air flow, leakage, there is in the cables of a flight, the greater magnitude of pressure differences and flow rates the simulator unit has to work with.

During normal conditions, most flights have an extreme difference in pressure throughout the flight of no more than one psi. This one psi pressure drop is obtained from the difference in measurements of 9

Attachment to Ltr.

and 10 psi. This is inherently an inaccurate way to measure a one psi pressure drop. Also, this small a pressure difference could be in the range of secondary effects, and no secondary effects are considered in the theory of the simulator units.

So far, field data and simulation results have only been compared on a flight average basis. This limited data shows no apparent field data-simulation results relationship has been found for a particular launch facility - lateral or any other arrangement of cable segments within a flight.

Field pressure readings of most flights are all within 10% of the simulated results with a compressor at all LF's and a leakage rate of 0.5 cubic feet/mile/day.

Field flow rates greater than the simulated results by 50% to over 100% occur at many launch facilities in most flights (simulator set with pressure at all LF's and a leakage rate of 0.5 cubic feet/mile/day).

Three possible causes of the above are:

- A. An excessive amount of the air leakage is in the facilities or near the facilities.
- B. The simulator units use too high a value of cable pneumatic resistance, R_p .
- C. Secondary effects of air flow.

Leaks in the facility and the first few adjacent splice cases have almost no effect on the pressure gradient, but these leaks could be the major part of the flow rate.

The values of R_p are for one thousand feet and each flight has nearly six hundred units of one thousand feet. Therefore, even a slightly high value of R_p for the overall flight would be significant because of the multiplication factor used in the application of R_p .

Almost all launch facilities in the wing are located on high ground relative to the far end of the lateral cable from the launch facility. This condition arises because of the launch control centers being by the main highways and the launch facilities being by secondary roads. The main highways are located in the valleys with the secondary roads branching out into the high ground. Therefore, any secondary effects on the air system because of air flowing down hill would be almost universally applicable to the wing.

Air Flow Units

Boeing comments, reference (b) in cover letter, is in error in its statement that the unit of air flow in the RCA simulator reports is cubic feet of air at the working pressure. The RCA reports unit of air flow is standard cubic feet.

The only calculations of R_p recorded by RCA are in their Cable Test Report MTOR-C-052-3. These calculations use the readings of a volume recording meter during stated time intervals to obtain air flow rates.

It appears from the pictures of the equipment that the volume recording meter is a LPG meter, low pressure gas meter, instead of a meter recording air flow at the working pressure in units of standard cubic feet as implied.

Another indication that the air flow rates in MTOR-C-052-3 are LPG meter readings is that the graph of pressure versus air flow does not pass through the origin of the graph, but the graph of the readings used as air at the working pressure converted to standard conditions does pass through the origin, see Figures A, B and C.

RCA had to extrapolate the MTOR-C-052-3 Rp values to obtain useful values to use in their simulation reports, see Appendix I Paragraph A in reference (a) of cover letter. A comparison of Rp values is shown in Figure D.

Final Simulation

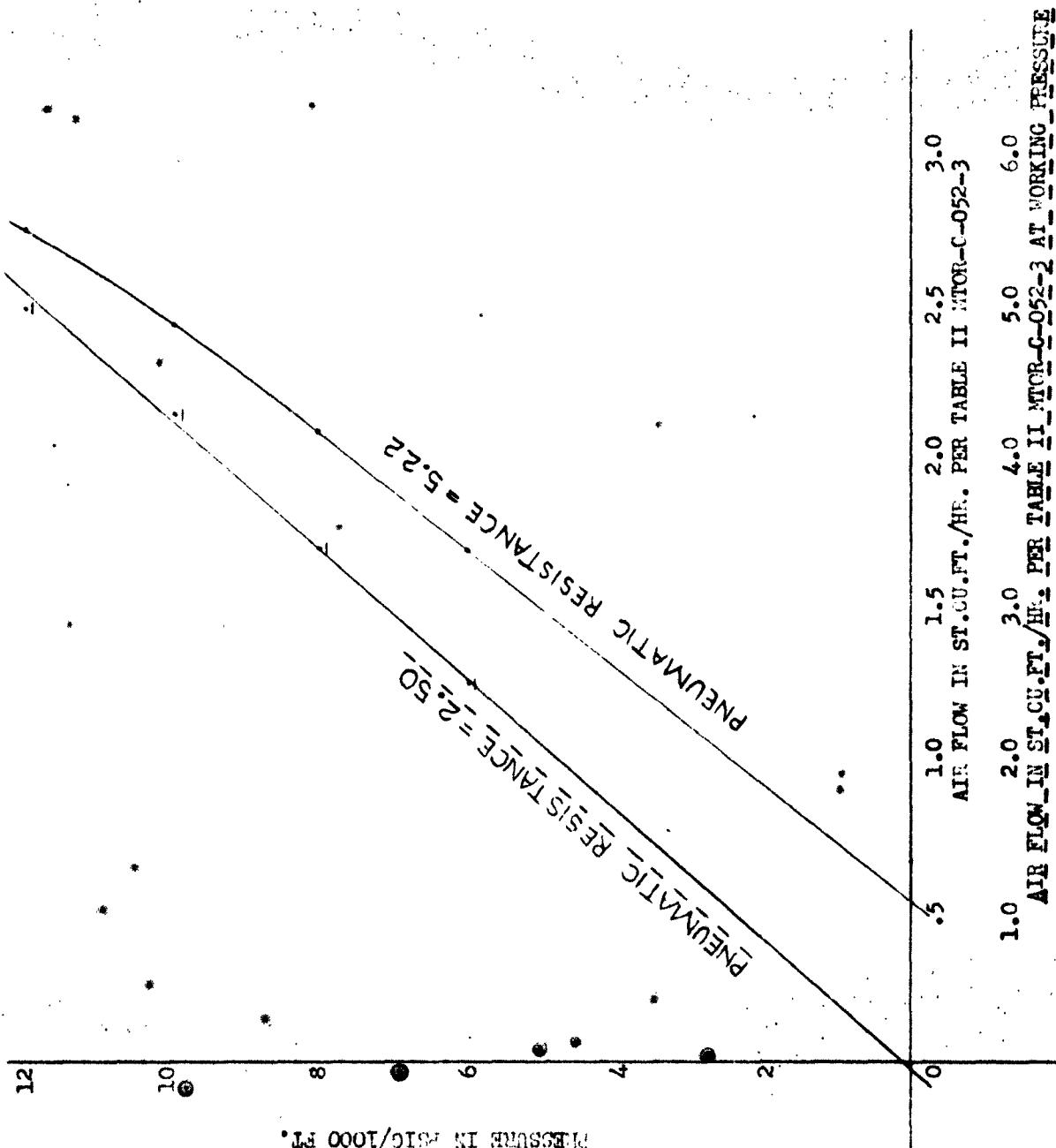
The final report, reference (a) in cover letter, contains the wing simulation results which show that interconnecting all the flight simulators into a wing simulator has no significant effect on the simulations of the individual flights.

The individual flight reports can be disregarded. The final report records the total simulation effort by cataloging the data of all the flight reports and by restating in a concise manner the theory of the simulator units.

In the final report it is possible to become confused when using the tables that compare the results of simulating the whole wing with two different ways of simulating each individual flight. This is because each comparison uses a different nomenclature for the whole wing simulation. The wing simulation data is recorded under the heading of Inter-flight Cables Connected in Table III and under the heading of Interconnected Flight Simulation in Table III-1.

Conclusion

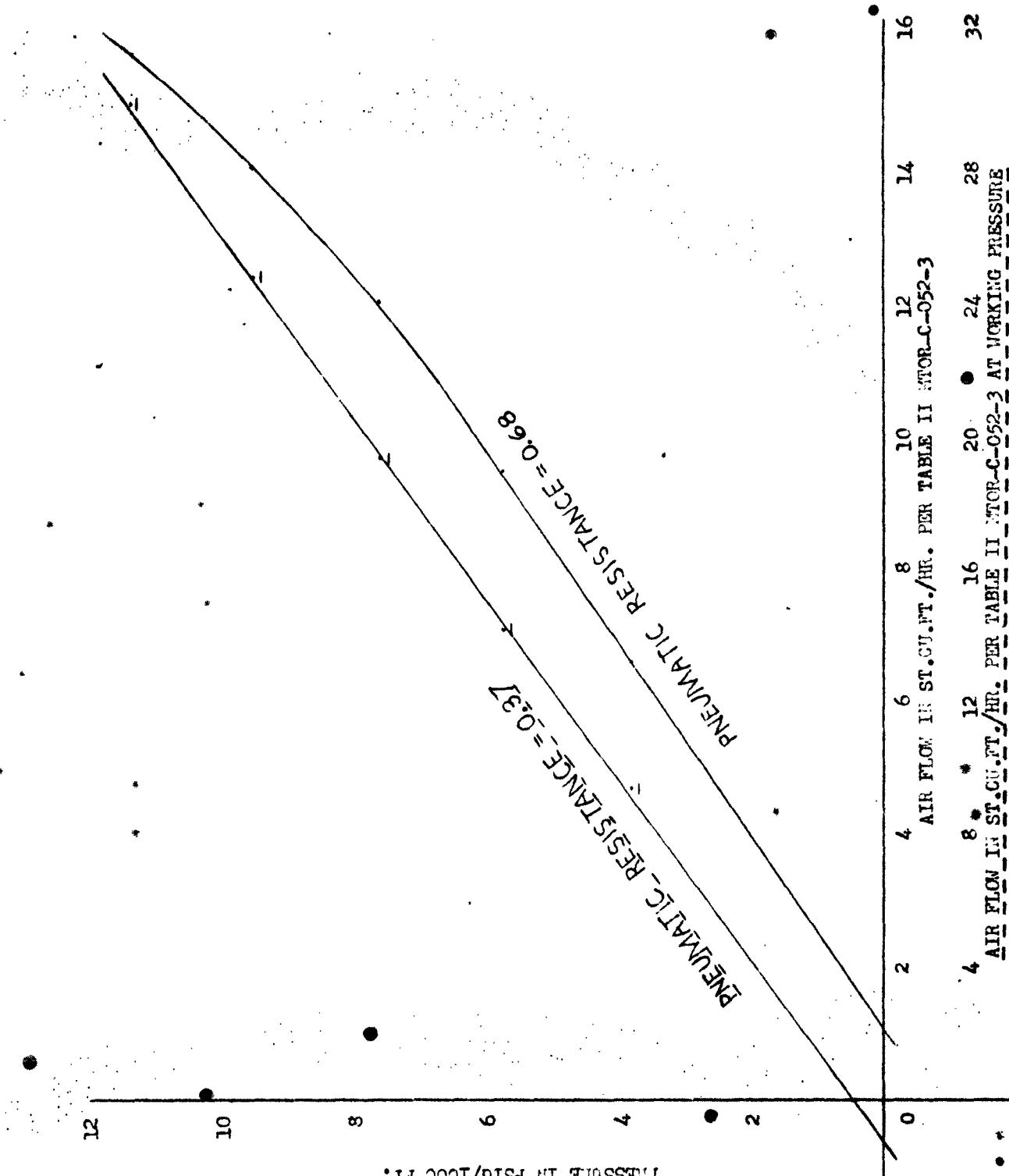
At present, no useful purpose can be seen for simulating the pneumatic system of operating flights having a pressure difference of one psi or less in the gradient range.



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FIGURE B
PNEUMATIC RESISTANCE
CABLE - 50 PAIR 19 AWG

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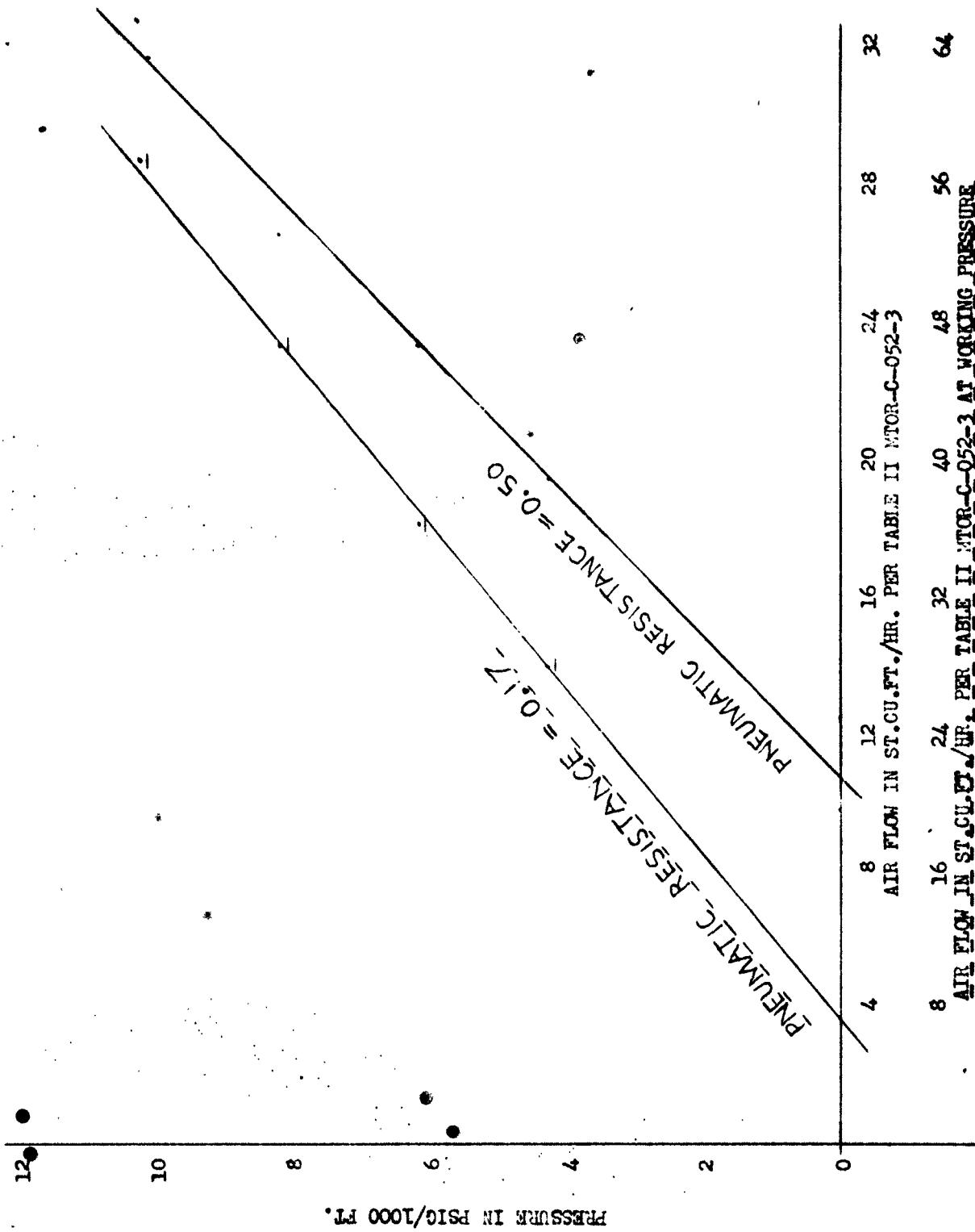


FIGURE C
PNEUMATIC RESISTANCE
CABLE - 25 PAIR 16 AWG

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FIGURE D

COMPARISON OF PNEUMATIC RESISTANCE
Rp IN PSIG/ CU. FT. PER FT., 1000 FT.

Gauge	Range of Rp Per Table II	Extrapolated Value of Rp Used In MTOR-C-052-3 Simulation Reports	Rp Using MTOR-C-052-3 Flow Data at Working Pressure
<u>No. Pair 16 AWG</u>			
6	1.24 - 1.84	1.22	1.00
25	0.21 - 0.31	0.15	0.17
<u>No. Pair 19 AWG</u>			
6	3.47 - 4.00	3.00	2.50
12	1.90 - 2.45	1.78	1.45
25	1.47 - 1.80	1.12	0.98
50	0.57 - 0.72	0.62	0.37